Reading Comprehension Lessons in AutoTutor for the Center for the Study of Adult Literacy

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Introduction and Overview of the Technology. The Center for the Study of Adult Literacy (CSAL) is a national research center that investigates reading problems in adults (those reading at the 3rd-8th grade levels) and that develops instructional interventions tailored to their needs. A web-based instructional tutor is a practical solution for comprehension instruction because many adults have busy schedules or transportation problems and because many literacy teachers have limited knowledge of comprehension training (NRC, 2011).

CSAL AutoTutor is an intelligent tutoring system on the web that delivers comprehension instruction. The system includes two computer agents that hold a conversation with the human and with each other (called *trialogues,* Graesser, Li, & Forsyth, 2014; McNamara, O'Reilly, Best, & Ozuru, 2006) and thereby guide the human in learning comprehension skills and using the computer facility.

The CSAL AutoTutor curriculum has 35 lessons with trialogues that focus on specific comprehension strategies. The AutoTutor lessons each take 10 to 50 minutes to complete and are assigned by teachers on the research team (in adult literacy centers) in a hybrid intervention with both teachers and computer facilities. The strategies are aligned with a PACES intervention (see below), which teachers have successfully implemented (face-to-face) to improve reading comprehension in high school students with reading difficulties (Lovett, Lacerenza, De Palma, & Frijters, 2012). It is beyond the scope of this short chapter to cover the PACES strategies in detail, but the descriptions below sketch the main components.

(1) *P*redicting the purpose and structure of the text with text signals.

(2) *A*cquiring vocabulary using context clues and affix knowledge.

(3) *C*larifying sources of confusion of explicit text through questioning.

(4) *E*valuating, explaining, and elaborating texts through inferences and questioning.

(5) *S*ummarizing and using text structures.

Adults with reading difficulties typically have substantial challenges with writing so the interface on CSAL AutoTutor tends to rely on point & click (or touch), multiple choice questions, drag & drop, and other conventional input channels. However, the system does include some writing components that require semantic evaluation of open-ended student contributions, which is the signature feature of AutoTutor systems (Graesser, Li, & Forsyth, 2014). CSAL AutoTutor has many pictures, diagrams, and multimedia that help grab and maintain the attention of the adult learner. The system also has the capability of reading texts aloud when the learner asks for such assistance by clicking on a screen option.

Figure 1 shows an example of trialogue design found in CSAL AutoTutor. There is a tutor agent at the top left and a peer agent at the top right. The passage below the agents is about receiving a General Education Degree (GED). The adult learner is asked to click on the sentence in the passage that supports the statement: "The writer did not learn about computers in high school." That would require the learner to understand the sentences in the passage and decide which sentence offers supportive information, which is an important comprehension skill.

INSERT FIGURE 1 ABOUT HERE

There are three components of CSAL AutoTutor that provide adaptive, intelligent interaction. The first assigns texts to read (or shorter instruction episodes) that are tailored to the student's ability (not too easy or too difficult), as calibrated by prior performance of the student. A lesson starts out with a text (or set of shorter items) at an intermediate difficulty level, but then upshifts or downshifts in the difficulty of the assigned materials in a manner that is sensitive to the learner's previous performance. The difficulty level of the texts is computed by *Coh-Metrix*, a system that scales texts on difficulty by considering characteristics of words, syntax, discourse

cohesion and text category (Graesser, McNamara et al., 2014; McNamara, Graesser, McCarthy, & Cai, 2014). After performance is scored on the questions associated with the initial text in a lesson, the next text assigned will be relatively difficult if the score of the learner is high and will be easy if the learner's score is low. The second adaptive component designs the trialogue conversations in a manner that adapts to student ability and/or motivation, as reflected in their performance scores during training. For example, the peer agent ends up losing to the human in Jeopardy-like game competitions between the human and peer agent. The human and peer agent take turns answering questions and score points in the competition that is guided by the tutor agent. The human's winning the competition with the peer agent is expected to boost the confidence of the adult learner. Third, the open-ended responses are assessed with computational linguistics techniques that match the student's input to expectations (Graesser & McNamara, 2012). Hint questions are generated to guide the student to fill in missing words and phrases of sentences that the learner is expected to enter.

There are auxiliary computer components of the CSAL package that augment the learning experience and motivation. Each AutoTutor lesson includes a short review video of the didactic instruction in a succinct 2-3 minute segment. The lessons are all based on practical topics that have high interest and value, such as selecting a new phone to purchase, filling out a job form, following a cooking recipe, or understanding prescription medicine. There is an electronic independent reading facility for the adult learners to use. This facility includes a text repository (i.e., a library) that has thousands of texts that are categorized on different topics (such as health, family, work, etc.) and that are scaled on reading difficulty. It also provides access to Simple English Wikipedia. They are encouraged to read documents on topics that interest them, with the guidance and encouragement of the teachers in the adult literacy centers.

The hope is that independent reading facility will increase their practice time and self-regulated learning.

A few other points need to be made about the CSAL AutoTutor series. First, assessments will be conducted on the independent reading, but it is beyond the scope of this chapter to address the independent reading facility that is designed to increase interest, motivation, and self-regulated reading. Second, there is an AutoTutor Script Authoring Tool (ASAT) for teachers and curriculum developers to develop new lessons with agents in a short amount of time. Third, the data collected during learning are organized in a data management system that is accessible in dashboards that are tailored to different stakeholders (students, teachers, and researchers).

Why the Technology is Needed. According to the 2011-2012 international study of adult literacy (the Program for the International Assessment of Adult Competencies, PIACC), adults in the United States scored below the international average in literacy, numeracy, and problem solving in technology rich environments (Goodman, Finnegan, Mohadjer, Krenzke, & Hogan, 2013). The US Department of Education reported in 2010 that over two million adults were enrolled in a federally funded adult education program to increase their skills. Unfortunately, these programs are beset with many obstacles: Poor funding, little professional development for teachers and tutors, high absenteeism and attrition rates, and a wide diversity of students in terms of racial, ethnic, and gender identities, age (between 16 and 80+), as well employment, educational, and language status. As a result of these obstacles, administering quality adult literacy instruction can be a challenge (Greenberg, 2008).

There is an increased use of computers in adult literacy classes (Kruidenier, 2002), in part because learners with varying reading skills can respond to web-based instruction (National Institute of Literacy, 2008). Technology can help overcome the obstacles in adult reading

programs. Given the diversity of learners in skills and interest, as well as the inadequate professional development of instructors, well-written, adaptive, intelligent tutorial programs can be beneficial. Attendance issues can be addressed by students being able to access the learning environments in their own homes, neighborhood libraries, schools, houses of worship, and/or locations of employment. The National Research Council's report (NRC, 2011) on adult literacy instruction also states that, "technology can be leveraged to create motivating environments for acquiring reading… that include … animated agents" (p. 9-13). Our web-based tutoring component includes conversational pedagogical agents who motivate and navigate the learner through learning lessons and activities. The system also has adaptive components that are sensitive to the ability of individual learners.

Plans for Development and Testing of Technology. The CSAL research team has already developed initial versions of the 35 lessons with trialogues. These can be used on the web and supported by most browsers. We have collected data on 52 adult learners in Toronto and Atlanta on 30 of the lessons in a feasibility study. These learners completed 71% of the lessons and answered 55% of the questions correctly. The lessons are currently being revised to accommodate feedback from teachers, adult learners, and performance data collected in log files. Between the winter of 2016 and the spring of 2017 there will be an experiment that compares an intervention with AutoTutor (plus teachers) with a comparison condition with teachers (without AutoTutor) on several hundred adult learners in Atlanta and Toronto. These assessments will guide revisions of CSAL AutoTutor so that a robust, well-tested system is developed by the end of 2017.

Timeline for Making the Technology Publically Available. Stand-alone versions of CSAL AutoTutor will be available in early 2016, but it is open question how it would be used

without the support of teachers. The timeline for making a version of CSAL AutoTutor available to the public depends on the results of testing and the computer infrastructure in place to handle different numbers of adult learners. The ideal vision is to have a web portal that can accommodate millions of adult learners.

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Figure 1. Example Screenshot of CSAL AutoTutor.

Having my GED would mean a lot to me. I believe I could accomplish a lot of things in my life. I could further my education. I could get into a career I've wanted since I was 12 years old. That career is working with computers. I used to dream about computers all of the time. I wanted to program and fix them. I wanted to know everything about them. When I got to high school, I didn't pay much attention to computers. I cut or was late for many of my classes. I

Click on the sentence above that supports the statement, "The writer did not learn about computers in high school."